Designation: D2561 – 17 (Reapproved 2023)

# Standard Test Method for Environmental Stress-Crack Resistance of Blow-Molded Polyethylene Containers[1]

This standard is issued under the fixed designation D2561; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 Under certain conditions of stress, and in the presence of environments such as soaps, wetting agents, oils, or detergents, blow-molded polyethylene containers exhibit mechanical failure by cracking at stresses appreciably below those that would cause cracking in the absence of these environments.

1.2 This test method measures the environmental stress crack resistance of blow-molded containers, which is the summation of the influence of container design, resin, blow-molding conditions, post treatment, or other factors that can affect this property. Three procedures are provided as follows:

1.2.1 *Procedure A, Stress-Crack Resistance of Containers to Potential Stress-cracking Liquids*—This procedure is particularly useful for determining the effect of container design on stress-crack resistance or the stress-crack resistance of a proposed container that contains a liquid product.

1.2.2 *Procedure B, Stress-Crack Resistance of a Specific Container to Polyoxyethylated Nonylphenol (CAS 68412-54-4), a Stress-Cracking Agent*—The conditions of test described in this procedure are designed for testing containers made from Class 3 polyethylene Specification D4976. Therefore, this procedure is recommended for containers made from Class 3 polyethylene only. This procedure is particularly useful for determining the effect of resin on the stress-crack resistance of the container.

1.2.3 *Procedure C, Controlled Elevated Pressure Stress-Crack Resistance of a Specific Container to Polyoxyethylated Nonylphenol (CAS 68412-54-4), a Stress-Cracking Agent*—The internal pressure is controlled at a constant elevated level.

NOTE 1—There are environmental concerns regarding the disposal of Polyoxyethylated Nonylphenol (Nonylphenoxy poly(ethyleneoxy) ethanol (CAS 68412-54-4), for example, Igepal CO-630). Users are advised to consult their supplier or local environmental office and follow the guidelines provided for the proper disposal of this chemical.

1.3 These procedures are not designed to test the propensity for environmental stress cracking in the neck of containers, such as when the neck is subjected to a controlled strain by inserting a plug.

1.4 The values stated in SI units are to be regarded as standard.

NOTE 2—There is no known ISO equivalent to this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 8 and Note 1.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D4976 Specification for Polyethylene Plastics Molding and Extrusion Materials

D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

E145 Specification for Gravity-Convection and Forced-Ventilation Ovens

## 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *failure*—during this test method, the formation of any imperfection, such as a crack, which results in a loss of pressurizing gas or stress-cracking agent.

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.1.1 *Discussion*—A container has failed when:

It has lost pressure through any aperture other than heat seal areas; or, in Procedure C, when there is a detectable flow of supply air into the bottle, there is any visible crack completely through the container wall, there is evidence of the contained liquid on the outside of the container through any aperture other than one at the heat-seal area, or the contained liquid volume has been reduced.

3.1.2 *potential stress-cracking liquids*—a liquid that can contain stress-cracking agents, which have the potential to induce a stress crack in the test containers.

3.1.2.1 *Discussion*—Under certain conditions of stress and in the presence of potential stress-cracking liquids such as soaps, wetting agents, oils, or detergents, ethylene plastics may exhibit mechanical failure by cracking.

3.1.3 *stress crack*—defined as a failure.

## 4. Summary of Test Method

4.1 Procedure A consists of exposing any filled, sealed, blow-molded container to the action of a potential stress-cracking agent within the container, at an elevated temperature. The time to failure is observed.

4.2 Procedure B consists of exposing a sealed blow-molded standard container, partly filled to one third of overflow capacity, to the action of polyoxyethylated nonylphenol, a stress-cracking agent, within the container, as well as to the action of this agent as an external environment, at an elevated temperature. The time to failure is observed.

4.3 Procedure C consists of exposing a blow-molded standard container, partly filled to one fourth of overflow capacity, to the action of polyoxyethylated nonylphenol, a stress-cracking agent, within the container, as well as to a constant elevated pressure internally applied and at an elevated temperature. The time-to-failure can be determined in a tactual-visual manner, or instrumentally.

NOTE 3—Partial filling, that is, one third of nominal capacity, has been found to increase the severity of the test with many test liquids. Thus, the partial fill can be used to accelerate the test. The use of an elevated controlled pressure as in Procedure C can also accelerate the test.

## 5. Significance and Use

5.1 When properly used, these procedures serve to isolate such factors as material, blow-molding conditions, post-treatment, and so forth, on the stress-crack resistance of the container.

5.2 Environmental stress cracking of blow-molded containers is governed by many factors. Since variance of any of these factors can change the environmental stress-crack resistance of the container, the test results are representative only of a given test performed under defined conditions in the laboratory. The reproducibility of results between laboratories on containers made on more than one machine from more than one mold has not been established.

5.3 Results can be used for estimating the shelf life of blow-molded containers in terms of their resistance to environmental stress cracking provided this is done against a rigorous background of practical field experience and reproducible test data.

## 6. Apparatus

6.1 *For Procedures A, B, and C:*

6.1.1 *Circulating-Air Oven,* consistent with ovens prescribed in Specification E145, except for size, capable of maintaining a temperature of 60 ± 1°C (140 ± 1.8°F) and an airflow rate of 8.5 to 17 $m^3$/min (300 to 600 $ft^3$/min). (**Warning—** A high-temperature safety switch is highly recommended on this oven. Some test liquids can cause extreme pressure buildup upon heating. Under these conditions bottles can rupture with explosive force. This condition can cause injury to the operator as well as damage to the ovens. The override cutoff switch should be set to turn off the oven heat if the test temperature is exceeded by as much as 10°C (18°F). )

6.1.2 *Balance,* accurate to within ±1.0 g (for weighing containers and contents) or a volumetric filling apparatus accurate to ±1 mL.

6.2 *For Procedures A and B Only:*

6.2.1 *Heat-Seal Laminate* for sealing the containers.

6.2.2 *Heat-Sealing Unit.*

6.2.3 *Torque Meter.*

6.2.4 *Glass Beakers,* large enough to hold the contents of one test container.

6.3 *For Procedures A and C Only:*

6.3.1 *Polyethylene Bags,* approximately 0.038-mm (1.5-mil) thick, large enough to enclose completely a test container. The bag should fit loosely around the container and be long enough so that the bag opening can be closed above the container closure.

6.4 *For Procedure C Only:*

6.4.1 The essential parts of this apparatus are schematically shown in Fig. 1. Additional refinements in failure detection can be added as shown in Fig. 2. The *necessary* equipment is as follows:

6.4.1.1 *Clear Air Supply* of sufficient pressure to operate regulator and maintain regulated pressure to manifold.

6.4.1.2 *Air Filter,* to remove oil, water, dust, and other contaminants.

6.4.1.3 *Pressure Regulator,* to reduce line pressure to 34.5 ± 1.72 kPa (5.0 ± 0.25 psig).

6.4.1.4 *Pressure Gauges,* calibrated to indicate a pressure of 34.5 kPa (5.0 psig) with a precision of 0.34 kPa (0.05 psig).

NOTE 4—A non-mercury manometer is of benefit in calibrating the pressure gauges, and monitoring precise pressure measurements.

6.4.1.5 *Air Valves.*

6.4.1.6 *Restricting Line Orifice or Needle Valve*—This restriction retards the flow of air to the bottle so that supply pressure remains constant after bottle failure, enabling a number of bottles to be pressurized from a single regulated supply. Pressure drop on the bottle side of this restriction is one indication of bottle failure. The orifice size or restriction used will depend upon the sensitivity of the pressure switch or gauge. Orifices that pass 300 $cm^3$ /min at 6.9 kPa (1 psi) differential pressure have been found satisfactory. Needle